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Avian community structure among restored riparian habitats in northwestern Mississippi

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Abstract

Riparian zones and agricultural fields adjacent to incised streams in northwestern Mississippi are impacted by gully erosion initiated by runoff flowing over unstable streambanks. Currently, installation of erosion control structures (drop pipes) at the riparian zone—agricultural field interface halts gully erosion and simultaneously establishes one of four riparian habitat types. Avian communities were compared among four types of restored habitats and among four seasonal periods in northwestern Mississippi from June 1994 to May 1996. Fifty-seven species were observed among riparian habitats, of which 49% were neotropical migrants. Habitat type and season significantly affected species richness, abundance, and diversity. Species richness, abundance, and diversity increased as habitat area, pool volume, and vertical structure of woody vegetation increased among riparian habitat types. Additionally, species richness, abundance, and diversity increased during spring and fall. The influence of habitat type on avian species richness, abundance, and diversity did not differ among seasons. Present drop pipe installation practices focus on erosion control without consideration of habitat creation. Installation practices can be altered to more effectively incorporate habitat creation to provide the greatest ecological benefits for avian communities within impacted riparian zones.
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Keywords: Avian communities; Riparian zones; Gully erosion; Habitat restoration; Erosion control; Mississippi

1. Introduction

Riparian zones are important habitats for birds, and often support greater levels of biodiversity than adjacent upland habitats within the watershed (Knopf et al., 1988). Riparian zones are often one of the few habitats remaining for birds within agroecosystems. Conservation of riparian zones within agricultural landscapes is vital for mitigating the effects of habitat fragmentation and intensive farming practices on avian communities (Keller et al., 1993; Deschenes et al., 2003). The impacts of agriculture on riparian birds have been evaluated by assessing how birds are influenced by riparian habitat characteristics, riparian vegetation, and adjacent land use characteristics (Keller et al., 1993; Saab, 1999; Deschenes et al., 2003; Henningsen and Best, 2005). However, streams within many agricultural riparian zones have been channelized for flood control and field drainage. Our understanding of the impacts of channelization (i.e., deepening, widening, and straightening of stream channels) and the habitat changes that occur following channelization on avian communities is limited (Nilsson and Dynesius, 1994).

Riparian zones in northwestern Mississippi consist of narrow vegetative corridors low in habitat diversity and lacking the typical floodplain–stream interaction because of the impacts of farming practices and channelization. Habitat fragmentation of riparian zones in northwestern Mississippi began with land clearing and cultivation of crops in the early 1800s. Avian habitat further declined as riparian zone width was reduced when forested areas adjacent to streams were cleared for agriculture. Stream channelization has also impacted riparian habitats in this region. Streambank

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erosion began after channelization was first conducted by landowners in the 1840s (Shields et al., 1995). Federal channelization projects conducted between 1930 and 1960 induced severe channel incision which resulted in destabilization of entire watersheds in this region (Shields et al., 1995). Oversteepened and enlarged streambank heights caused by channel incision frequently results in gully erosion that rapidly migrates perpendicular to the stream through the riparian zone and into the agricultural field.

Gully erosion is the most severe form of soil erosion and can result in soil loss rates between 0.1 and 65 t ha^{-1} $year^{-1}$ (Poesen et al., 2003). The most common practice used to control gully erosion associated with incised streams in this region is the field-scale grade control structure (drop pipe). The structure consists of an earthern dam with an embedded L-shaped metal pipe, and similar structures are used nationally and internationally to control gully erosion (Shields et al., 2002). Drop pipe installation halts gully erosion and allows for the incidental development of riparian habitat that reconnects riparian zones fragmented by gully erosion (Cooper et al., 1997). The high frequency of gully erosion adjacent to deeply incised streams in northwestern Mississippi has resulted in the installation of thousands of drop pipes adjacent to these waterways (Shields et al., 2002).

Our objective was to characterize avian community structure within riparian habitats established by the installation of drop pipes. Specifically, comparisons of species composition, species richness, abundance, and diversity among four types of restored riparian habitats and four seasons were made. Our study allowed us to examine the influence of different combinations of habitat characteristics on avian communities and to assess whether the influence of habitat characteristics varied with season.

2. Methods

A pre-study survey of 180 drop pipe sites within the Yazoo River watershed indicated that restored habitats fit one of four discrete types on the basis of habitat area, pool volume, and vegetative structure (Table 1). Subsequent plant censuses and total station surveys (Shields et al., 2002) supported our initial habitat classification. Type I habitats were the smallest riparian patches and composed mostly of herbaceous vegetation (Table 1). The four dominant plant species within Type I habitats were bermuda grass (*Cynodon dactylon* (L.) Pers), goldenrod (*Solidago* spp.), paspalum grass (*Paspalum* spp.), and panic grass (*Panicum* spp.). Type II habitats were larger riparian patches than Type I habitats (Table 1) and were composed of herbaceous vegetation mixed with shrubs and saplings. The four dominant plant species within Type II habitats were Japanese honeysuckle (*Lonicera japonica* Thunb.), goldenrod, white ash (*Fraxinus americana* L.), and blackberry (*Rubus argutus* Link). Type

Table 1
Mean total habitat area (m^2), mean maximum pool volume (m^3), mean plant species richness (plant richness), and mean vertical structure of woody vegetation index within four restored riparian habitat types in northwestern Mississippi, June 1994–May 1996

Habitat type	Habitat area	Pool volume	Plant richness	Vertical structure index[a]
Type I ($n = 4$)	600	14.8	22.3	0.01
Type II ($n = 4$)	1000	41.4	22.3	0.21
Type III ($n = 4$)	1300	425.5	26.3	0.30
Type IV ($n = 4$)	3700	1343.4	46.3	0.20

See Shields et al. (2002) for description of sampling methods for all response variables.

[a] Index of vertical structure indicates dominance of woody vegetation greater than 1.8 m tall and ranges in scores from 0 (site lacking woody vegetation >1.8 m tall) to 1 (site dominated by woody vegetation >1.8 m tall) (Shields et al., 2002).

III habitats were riparian patches larger than Type II habitats (Table 1) and characterized by the presence of an ephemeral pool surrounded by a ring of woody vegetation. The four most occurring plant species were black willow (*Salix nigra* Marsh.), bermuda grass, ragweed (*Ambrosia artemisiifolia* L.), and the non-native kudzu (*Pueraria lobata* (Willd.) Ohwi). Type IV habitats were characterized by having the greatest habitat area, permanent pools, greatest plant species richness (Table 1), and an input channel extending into the field. Vegetation within Type IV habitats consisted of woody and herbaceous vegetation, and the four most frequently occurring plant species were blackberry, goldenrod, partridge pea (*Cassia fasiculata* Michx.), and bermuda grass. The amount of woody vegetation within a site varied more among Type IV habitats than Type III habitats. Type IV habitats ranged from sites composed of predominantly herbaceous vegetation with a few mature trees >2 m tall to sites that contained pools and input channels surrounded by mature trees >2 m tall. Type IV habitats were distinguished by having the largest trees and common woody species included black willow, American elm (*Ulmus americana* L.), sycamore (*Platanus occidentalis* L.), and sweet gum (*Liquidamber styraciflua* L.).

The pre-study survey of 180 drop pipe sites also found that Type I habitats occurred most frequently (61%), followed in abundance by Type III (21%), Type II (11%), and Type IV (7%) habitats (Shields et al., 1995). We selected four sites of each habitat type within the Long and Hotophia Creek watersheds in Panola County, Mississippi (latitude 34°9′–34°33N, longitude 89°43′–90°11′W) as study sites (total 16 sites). Both watersheds were predominantly agricultural watersheds primarily devoted to cotton (*Gossypium* spp.) production. All study sites were adjacent to deeply incised streams and agricultural fields. We attempted to control for landscape influences by choosing sites that were adjacent to cotton fields. Fifteen sites were adjacent to cotton fields, but logistical matters required us to select one site adjacent to a corn (*Zea* spp.) field.

2.1. Bird censuses

Ten minute unlimited radius point counts were conducted from the dam of the structure within each site. Bird sampling was conducted in summer (June–August), fall (September–November), winter (December–February), and spring (March–May) from June 1994 to May 1996. A total of 844 point counts were conducted during the study, and the number of counts at each site ranged from 10 to 16 per season. Examination of species–area curves from the first field season indicated that 14–16 point counts were needed to document 80% of all species within each habitat type. For the entire study period, mean number of point counts was similar among habitat categories (Type I = 52.0, Type II = 53.3, Type III = 53.3, and Type IV = 52.5) but varied slightly among seasons (summer = 43.0, fall = 61.5, winter = 48.3, and spring = 58.3). Censuses were conducted between 06:00 and 11:30 (CST). Censusing order of each site was rotated among observers and time of day to account for potential observer and temporal biases. Only birds identified to the species level and observed perching or feeding within drop pipe created habitats were included in the data analyses.

2.2. Data analyses

Species richness, abundance, Shannon index (H'), and Simpson's index (D) were calculated for each site during each season using composited point count information from each site and season. Data were pooled among years because we were not interested in annual effects. Examination of differences in mean species richness and abundance among years supported our decision to pool the data because no significant differences in mean species richness (Mann–Whitney test, $T = 3689$, $P = 0.759$) or abundance (Mann–Whitney test, $T = 3596$, $P = 0.860$) were observed. Species richness was the total number of species observed, and abundance was the total number of birds sighted. H' and D were calculated using the methods of Magurran (1988).

The effects of habitat type and season on species richness, abundance, H', and D were examined. A two factor ANOVA and a Student–Neuman–Keuls (SNK) test were used to examine how species richness and abundance differed among habitat types and seasons. Species richness and abundance were log $(x + 1)$ transformed prior to analyses to satisfy ANOVA assumptions. H' and D failed to meet assumptions of ANOVA despite the $\log(x + 1)$ transformation. Instead, a nonparametric two factor ANOVA and a nonparametric analogue to the SNK test (Zar, 1984) was used to assess differences in H' and D among habitat types and season. All parametric tests were conducted using SigmaStat 2.0 for Windows (Jandel Corporation, 1995), while nonparametric tests were conducted by hand calculation. The significance level for parametric and nonparametric ANOVA analyses was $P < 0.05$.

Detrended correspondence analyses (DCA) were conducted on relative abundance of avian species from each season to examine the similarity in species composition among habitat types in each season. Species that only occurred within one site were omitted from the DCA analyses and rare species were downweighted to reduce the influence of rare species on ordination results. DCA analyses were conducted using PC-ORD for Windows (McCune and Mefford, 1999).

3. Results

Fifty-seven species from 613 observations were identified among all habitat types and seasons (Table 2). The five most frequently observed species in all habitat types were northern cardinal, red-winged blackbird, song sparrow, common yellowthroat, and indigo bunting. No species was observed exclusively within Type I habitats, but the American goldfinch was most frequently observed within this habitat type. White-throated sparrow, pileated woodpecker, and solitary vireo were observed only within Type II habitats, while ruby-crowned kinglet, wood thrush, chimney swift, common grackle, loggerhead shrike, and prairie warbler were only sighted within Type III habitats. Seventeen species were observed exclusively within Type IV habitats, and included species such as killdeer, northern rough-winged swallow, yellow warbler, and black-throated green warbler (Table 2). Overall, neotropical migrants exhibited the greatest species richness among all habitat types, while short-distance migrants were the most abundant. All three migratory classes exhibited the greatest richness and abundance in Type IV habitats (Table 3).

Species richness ($F_{3,48} = 61.09$, $P < 0.001$), abundance ($F_{3,48} = 38.80$, $P < 0.001$), H' ($\chi^2_{0.05,3} = 34.25$, $P < 0.05$), and D ($\chi^2_{0.05,3} = 29.87$, $P < 0.05$) were different among habitat types (Table 4). Species richness was lowest within Type I habitats, and Type II habitats had a lower species richness than Type III and Type IV habitats. Avian abundance followed the same patterns among habitats as that of species richness (Table 4). Among all habitat types, H' and D were the lowest within Type I ($P < 0.05$), and similar among Type II, Type III, and Type IV habitats (Table 4). Seasonal effects were detected for species richness ($F_{3,48} = 8.41$, $P < 0.001$), abundance ($F_{3,48} = 4.09$, $P < 0.05$), and H' ($\chi^2_{0.05,3} = 9.02$, $P < 0.05$) (Table 4). In general, mean species richness, abundance, and H' were greatest in the fall and spring (Table 4). A significant interaction effect of habitat and season was not detected for any response variable.

Considerable overlap in species composition was observed among all habitat types in all seasons (Fig. 1). However, changes in the similarity in species composition within habitat types were observed among sampling seasons, which highlights how species composition within habitat types changes among seasons (Fig. 1). Type III and

Table 2
Percentage (numbers) of individuals of each species observed within each riparian habitat type established by drop pipe installation in northwestern Mississippi, June 1994–May 1996

Species	Type I ($n = 4$)	Type II ($n = 4$)	Type III ($n = 4$)	Type IV ($n = 4$)
Northern cardinal, *Cardinalis cardinalis* (Linnaeus)	–	19.5 (26)	22.4 (45)	19.0 (50)
Red-winged blackbird, *Agelaius phoeniceus* (Linnaeus)	–	15.8 (21)	22.4 (45)	19.8 (52)
Song sparrow, *Melospiza melodia* (Wilson)	18.8 (3)	13.5 (18)	6.0 (12)	19.0 (50)
Common yellowthroat, *Geothlypis trichas* (Linnaeus)	6.3 (1)	10.5 (14)	5.0 (10)	5.3 (14)
Indigo bunting, *Passerina cyanea* (Linnaeus)	–	4.5 (6)	7.5 (15)	3.0 (8)
Field sparrow, *Spizella pusilla* (Wilson)	25.0 (4)	8.3 (11)	1.5 (3)	0.4 (1)
House sparrow, *Passer domesticus* (Linnaeus)	–	3.8 (5)	0.5 (1)	3.0 (8)
American tree sparrow, *Spizella arborea* (Wilson)	–	1.5 (2)	2.5 (5)	2.3 (6)
Carolina chickadee, *Poecile carolinensis* (Audubon)	–	2.3 (3)	3.0 (6)	1.1 (3)
Cedar waxwing, *Bombycilla cedrorum* (Vieillot)	–	–	5.5 (11)	0.4 (1)
Eastern bluebird, *Sialia sialis* (Linnaeus)	–	3.0 (4)	3.5 (7)	0.4 (1)
American robin, *Turdus migratorius* (Linnaeus)	–	–	3.5 (7)	1.1 (3)
American goldfinch, *Carduelis tristis* (Linnaeus)	43.8 (7)	–	–	0.8 (2)
Carolina wren, *Thryothorus ludovicianus* (Latham)	6.3 (1)	0.8 (1)	1.5 (3)	1.1 (3)
Blue jay, *Cyanocitta cristata* (Linnaeus)	–	1.5 (2)	2.5 (5)	–
Eastern kingbird, *Tyrannus tyrannus* (Linnaeus)	–	–	0.5 (1)	1.9 (5)
Northern mockingbird, *Mimus polyglottos* (Linnaeus)	–	0.8 (1)	0.5 (1)	1.5 (4)
Yellow-rumped warbler, *Dendroica coronata* (Linnaeus)	–	–	1.5 (3)	1.1 (3)
Blue grosbeak, *Passerina caerulea* (Linnaeus)	–	–	1.5 (3)	0.8 (2)
Savannah sparrow, *Passerculus sandwichensis* (Gmelin)	–	2.3 (3)	–	0.8 (2)
White-throated sparrow, *Zonotrichia albicollis* (Gmelin)	–	3.8 (5)	–	–
Yellowbreasted chat, *Icteria virens* (Linnaeus)	–	3.0 (4)	–	0.4 (1)
Downy woodpecker, *Picoides pubescens* (Linnaeus)	–	–	1.5 (3)	0.4 (1)
Killdeer, *Charadrius vociferous* (Linnaeus)	–	–	–	1.5 (4)
Northern rough-winged swallow, *Stelgidopteryx serripennis* (Audubon)	–	–	–	1.5 (4)
Ruby-throated hummingbird, *Archilochus colubris* (Linnaeus)	–	0.8 (1)	1.5 (3)	–
Yellow warbler, *Dendroica petechia* (Linnaeus)	–	–	–	1.5 (4)
Brown thrasher, *Toxostoma rufum* (Linnaeus)	–	–	0.5 (1)	0.8 (2)
Gray catbird, *Dumetella carolinensis* (Linnaeus)	–	–	0.5 (1)	0.8 (2)
Hairy woodpecker, *Picoides villosus* (Linnaeus)	–	0.8 (1)	–	0.8 (2)
Swamp sparrow, *Melospiza georgiana* (Latham)	–	0.8 (1)	–	0.8 (2)
Black-throated green warbler, *Dendroica virens* (Gmelin)	–	–	–	0.8 (2)
Black-and-white warbler, *Mniotilta varia* (Linnaeus)	–	–	0.5 (1)	0.4 (1)
Cliff swallow, *Petrochelidon pyrrhonta* (Vieillot)	–	–	–	0.8 (2)
Dark-eyed junco, *Junco hyemalis* (Linnaeus)	–	0.8 (1)	–	0.4 (1)
Eastern meadowlark, *Sturnella magna* (Linnaeus)	–	0.8 (1)	–	0.4 (1)
Eastern phoebe, *Sayornis phoebe* (Latham)	–	–	–	0.8 (2)
Lousiana waterthrush, *Seiurus motacilla* (Vieillot)	–	–	0.5 (1)	0.4 (1)
Mourning dove, *Zenaida macroura* (Linnaeus)	–	–	–	0.8 (2)
Ruby-crowned kinglet, *Regulus calendula* (Linnaeus)	–	–	1.0 (2)	–
White-eyed vireo, *Vireo griseus* (Boddaert)	–	–	–	0.8 (2)
Wood thrush, *Hylocichla mustelina* (Gmelin)	–	–	1.0 (2)	–
American crow, *Corvus brachyrhynchos* (Brehm)	–	–	–	0.4 (1)
Barn swallow, *Hirundo rustica* (Linnaeus)	–	–	–	0.4 (1)
Chimney swift, *Chaetura pelagica* (Linnaeus)	–	–	0.5 (1)	–
Common grackle, *Quiscalus quiscula* (Linnaeus)	–	–	0.5 (1)	–
Dickcissel, *Spiza americana* (Gmelin)	–	–	–	0.4 (1)
Great blue heron, *Ardea herodias* (Linnaeus)	–	–	–	0.4 (1)
Green heron, *Butorides virescens* (Linnaeus)	–	–	–	0.4 (1)
Loggerhead shrike, *Lanius ludovicianus* (Linnaeus)	–	–	0.5 (1)	–
Baltimore oriole, *Icterus galbula* (Linnaeus)	–	–	–	0.4 (1)
Pine warbler, *Dendroica pinus* (Wilson)	–	–	–	0.4 (1)
Pileated woodpecker, *Dryocopus pileatus* (Linnaeus)	–	0.8 (1)	–	–
Prairie warbler, *Dendroica discolor* (Vieillot)	–	–	0.5 (1)	–
Solitary vireo, *Vireo solitarius* (Wilson)	–	0.8 (1)	–	–
Tennessee warbler, *Vermivora peregrina* (Wilson)	–	–	–	0.4 (1)
Yellow-bellied sapsucker, *Sphyrapicus varius* (Linnaeus)	–	–	–	0.4 (1)

Species are ordered from greatest to least based on their overall relative abundance from all habitat types combined.

Table 3
Species richness and abundance of neotropical migrants, short-distance migrants, and resident birds within riparian habitats established by drop pipe installation in northwestern Mississippi, June 1994–May 1996

Habitat type	Neotropical		Short-distance		Resident	
	Richness	Abundance	Richness	Abundance	Richness	Abundance
Type I ($n = 4$)	1	1	3	14	1	1
Type II ($n = 4$)	8	32	9	66	6	35
Type III ($n = 4$)	15	60	11	89	4	52
Type IV ($n = 4$)	22	66	17	131	7	66

Migratory status of each bird species was determined from Smith and Pashley (1994) or Alsop (2001).

Table 4
Habitat and season factor means (S.E.) for species richness, abundance, Shannon index (H'), and Simpson's index (D) in restored riparian habitats in northwestern Mississippi, June 1994–May 1996

Factor	Level	Richness	Abundance	H'	D
Habitat type	Type I ($n = 16$)	0.44 (0.13) C	1.00 (0.45) C	0.00 (0.00) B	0.25 (0.11) B
	Type II ($n = 16$)	3.50 (0.68) B	8.31 (1.67) B	0.80 (0.19) A	4.20 (1.29) A
	Type III ($n = 16$)	4.94 (0.49) A	12.56 (2.07) A	1.30 (0.10) A	4.67 (0.90) A
	Type IV ($n = 16$)	6.29 (0.85) A	16.44 (2.91) A	1.44 (0.10) A	5.47 (0.84) A
Season	Summer ($n = 16$)	2.81 (0.55) BC	6.38 (1.58) B	0.71 (0.16) B	2.92 (0.98) A
	Fall ($n = 16$)	3.69 (0.61) B	9.44 (2.17) AB	0.90 (0.18) AB	3.46 (0.94) A
	Winter ($n = 16$)	2.50 (0.50) C	7.06 (1.81) B	0.66 (0.16) B	2.91 (0.98) A
	Spring ($n = 16$)	6.06 (1.10) A	15.44 (3.26) A	1.29 (0.21) A	5.29 (1.10) A

Different letters indicate significant differences ($P < 0.05$) in means among habitat type or season for each response variable.

IV sites exhibited greater similarity in species composition than Type II sites in the summer (Fig. 1). Type I sites were omitted from the summer analysis because either no birds were sighted within these habitats during this sampling period or those species observed were considered rare species (i.e., observed in only one site). Type II, III, and IV sites had more similar species composition than Type I sites in the fall (Fig. 1). Species composition of Type II sites were most similar in the winter, while Type III and IV sites exhibited the greatest dissimilarity (Fig. 1). One Type I site was included in the winter DCA analysis and it was most similar in species composition to Type II sites (Fig. 1). Type III and IV sites exhibited greater similarity in species composition in the spring compared with Type II habitats (Fig. 1). The spring DCA analysis included only one Type I site, and this site was most similar in species composition to Type II sites (Fig. 1). Also, gradient lengths of DCA axes suggested high variability of species composition within all seasons. Gradient lengths of the first DCA axes ranged from 2.8 to 6.4 indicating that between 75 and 100% turnover in species composition occurred along the first DCA axes (Gauch, 1982). Gradient lengths of the second DCA axes were between 1.6 and 3.5 indicating that between 59 and 91% turnover in species composition occurred along the second DCA axes (Gauch, 1982).

4. Discussion

We observed that increases in avian species richness, abundance, and diversity occurred as habitat area, pool volume, and vertical structure of woody vegetation increased among restored habitats. Species richness, abundance, and diversity were also the greatest during migration periods of spring and fall. However, the influence of habitat type on avian species richness, abundance, and diversity did not differ among seasons. Distinct differences in species composition among habitat types were not observed due to the considerable variation in species composition that occurred among habitat types in all sampling seasons.

Management recommendations for riparian habitats within agricultural landscapes often involve facilitating the development of woody vegetation and increasing the habitat area of riparian zones. These recommendations stem from the results of studies within riparian areas and other remnant habitat types within agroecosystems that have documented the importance of these habitat features for avian communities. In general, avian richness and abundance increase with increasing amounts of woody vegetation (Fuller et al., 2001; Deschenes et al., 2003; Henningsen and Best, 2005). Increasing habitat area also results in increases in the avian species richness and abundance (Freemark and Merriam, 1986; Keller et al., 1993; Vanhinsbergh et al., 2002). Our results are consistent with these findings because we observed the greatest avian species richness and abundance within those habitat types with the greatest amounts of woody vegetation and the greatest habitat area (Type III and IV habitats).

However, our results cannot be attributed solely to the presence of woody vegetation and increases in habitat area, as riparian habitat types containing the greatest species

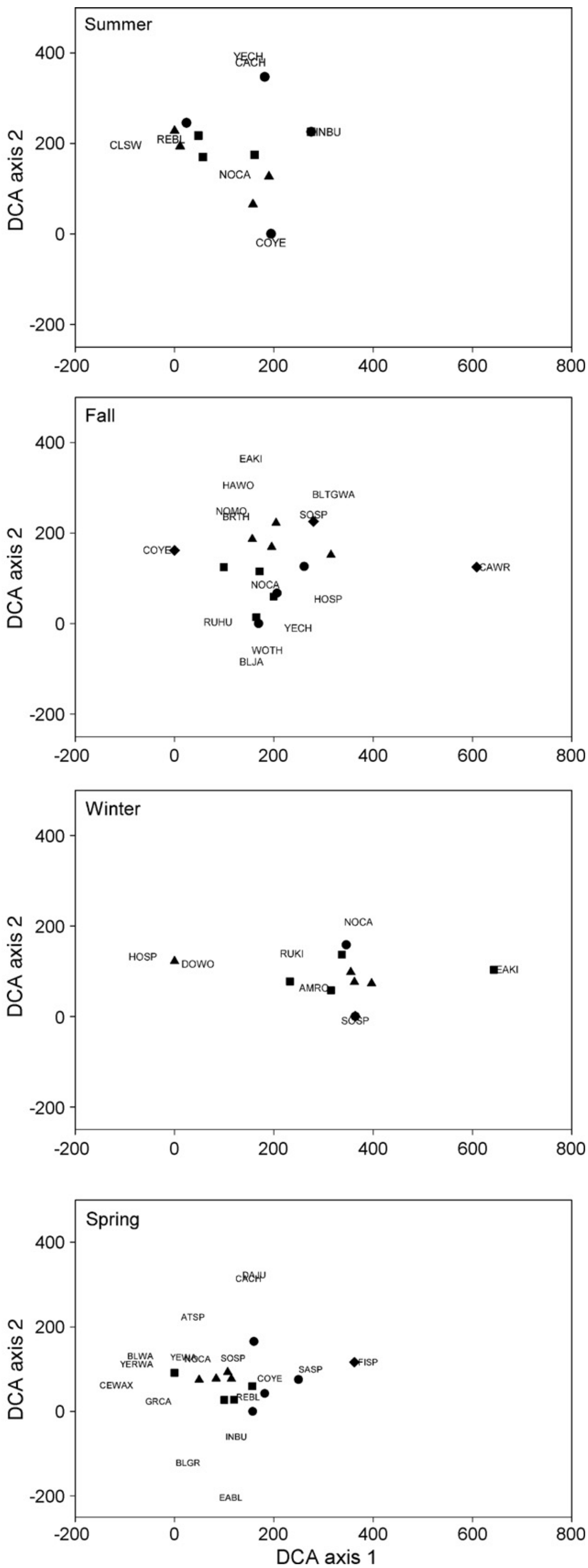

Fig. 1. Detrended correspondence analyses (DCA) of the percentage of avian species within four riparian habitat types in northwestern Mississippi during the summer, fall, winter, and spring, June 1994–May 1996. Habitat types are differentiated by different shapes within the figures: (◆) Type I sites; (●) Type II sites; (■) Type III sites; (▲) Type IV sites. Species codes are: AMRO, American robin; ATSP, American tree sparrow; BLGR, blue grosbeak; BLJA, blue jay; BLTGWA, black-throated green warbler; BLWA, black-and-white warbler; BRTH, brown thrasher; CACH, carolina chickadee; CAWR, carolina wren; CEWAX, cedar waxwing; CLSW, cliff swallow; COYE, common yellowthroat; DAJU, dark-eyed junco; DOWO, downy woodpecker; EABL, eastern bluebird; EAKI, eastern kingbird; FISP, field sparrow; GRCA, gray catbird; HAWO, hairy woodpecker; HOSP, house sparrow; INBU, indigo bunting; NOCA, northern cardinal; NOMO, northern mockingbird; REBL, red-wing blackbird; RUHU, ruby-throated hummingbird; RUKI, ruby-crowned kinglet; SASP, savannah sparrow; SOSP, song sparrow; WOTH, wood thrush; YECH, yellowbreasted chat; YERWA, yellow-rumped warbler; YEWA, yellow warbler.

richness and abundance also contained well developed pools. Information on the influence of pool development on riparian avian communities is limited because most studies examined the influence of terrestrial habitat features (i.e., vegetative characteristics and habitat area). In Mississippi, floodplain pools no longer develop within many riparian zones because the floodplain–stream interaction has been severed by the widespread occurrence of channel incision. Therefore, Type III and IV habitats are contributing to increased landscape diversity within these impacted riparian zones. Increased pool development within Type III and Type IV habitats may increase microhabitat diversity within restored habitats by altering plant species composition and vegetative structure. Pool development also provides a potential food source for insectivorous birds by supporting populations of emergent macroinvertebrates having aquatic larvae.

Four species (wood thrush, white-eyed vireo, loggerhead shrike, and field sparrow) observed within drop pipe created habitats are of high conservation concern and have exhibited declining populations in Mississippi (Smith and Pashley, 1994). Notably, four of the six most abundant species observed within restored riparian habitats (red-winged blackbird, common yellowthroat, indigo bunting, and field sparrow) have exhibited population decreases between 1980 and 1999 in the east-central United States (Murphy, 2003). We also observed 28 species of neotropical migrants and these species are also of high conservation interest (Finch and Stangel, 1993). These observations suggest that riparian habitats created by drop pipes have the potential to provide habitat for avian species of concern as well as cosmopolitan species.

Drop pipe installation and subsequent habitat creation does not create isolated habitat patches completely surrounded by agricultural fields, but instead reconnects riparian zones that have been fragmented by gully erosion and in some cases increases the riparian width. Larger riparian habitats (i.e., Types III and IV) may extend into the agricultural fields, but they are extensions of the riparian zone and are not isolated units. We estimated the total area of riparian habitat that will be created by drop pipe installation within the Yazoo River watershed by summing the products of the quantity of each habitat type and the mean area of each habitat type (reported in Table 1). The quantity of each habitat type is the product of creation frequency of each habitat type (reported in Section 2) and the total number of drop pipe structures installed and planned [i.e., 2800 (Trest, 1997)]. Current drop pipe installation practices have created an estimated 2.82 km^2 (282 ha) of riparian habitat in the Yazoo River watershed. This increase in habitat area may not enable these impacted riparian habitats to support self-contained breeding populations of area-sensitive species (Morton, 1992). However, remnant habitats for birds within large expanses of farmland are valuable even if these habitats are functioning as reproductive sinks for area-sensitive and migratory species (Morton, 1992), because they can function as dispersal routes, stop over points, food sources, and habitat for these and other avian species (Fuller et al., 2001). The potential of these habitats in functioning as population sinks would be related to their high edge to area ratio, and thus increased nest predation (Gates and Gysel, 1978). However, potential nest predator species richness and abundance did not differ among these riparian habitat types (Maul et al., 2005).

5. Conclusions

Presently, drop pipe installation focuses on gully erosion control without consideration of habitat restoration. Increases in avian species richness, abundance, and diversity and changes in species composition were observed as increases in habitat area, pool development, and vegetative structure occurred among riparian habitats restored by drop pipes in northwestern Mississippi. Additionally, Type III and IV habitats possessing the greatest avian species richness and abundance were the least frequently created habitat types. Furthermore, 61% of all species and 68% of neotropical migrants were sighted less than five times within restored habitats suggesting that additional habitat alterations are necessary for optimal avian use. Future research examining avian habitat use within created riparian habitats and surrounding habitats is necessary to formulate management actions that will provide the greatest benefits for avian communities.

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References

Alsop III, F.J., 2001. Smithsonian Birds of North America. DK publishing, New York, NY, 1008 pp.

Cooper, C.M., Smiley Jr., P.C., Wigginton, J.D., Knight, S.S., Kallies, K.W., 1997. Vertebrate use of habitats created by installation of field-scale erosion control structures. J. Freshwat. Ecol. 12, 199–207.

Deschenes, M., Belanger, L., Giroux, J., 2003. Use of farmland riparian strips by declining and crop damaging birds. Agric. Ecosyst. Environ. 95, 567–577.

Finch, D.M., Stangel, P.W., 1993. Introduction. In: Finch, D.M., Stangel, P.W. (Eds.), Status and Management of Neotropical Migratory Birds. General Report RM-229. U.S. Department of Agriculture, pp. 1–4.

Freemark, K.E., Merriam, H.G., 1986. Importance of area and habitat heterogeneity to bird assemblages in temperate forest fragments. Biol. Conserv. 36, 115–141.

Fuller, R.J., Chamberlain, D.E., Burton, N.H.K., Gough, S.J., 2001. Distributions of birds in lowland agricultural landscapes of England and Wales: how distinctive are bird communities of hedgerows and woodland? Agric. Ecosyst. Environ. 84, 79–92.

Gates, J.E., Gysel, L.W., 1978. Avian nest dispersion and fledging success in field-forest ecotones. Ecology 59, 871–883.

Gauch, H.G., 1982. Multivariate Analysis in Community Ecology. Cambridge University, New York, NY, 312 pp.

Henningsen, J.C., Best, L.B., 2005. Grassland bird use of riparian filter strips in southeast Iowa. J. Wildl. Manage. 69, 198–210.

Jandel Corporation, 1995. SigmaStat for Windows Version 2.0. Statistical Software. Jandel Corporation, San Rafael, CA.

Keller, C.M.E., Robbins, C.S., Hatfield, J.S., 1993. Avian communities in riparian forests of different widths in Maryland and Delaware. Wetlands 13, 137–144.

Knopf, F.L., Johnson, R.R., Rich, T., Samson, F.B., Szaro, R.C., 1988. Conservation of riparian ecosystems in the United States. Wilson Bull. 100, 272–284.

Magurran, A.E., 1988. Ecological Diversity and its Measurement. Croom Helm, London, UK, 179 pp.

Maul, J.D., Smiley Jr., P.C., Cooper, C.M., 2005. Patterns of avian nest predators and a brood parasite among restored riparian habitats in agricultural watersheds. Environ. Monit. Assess. 2005, 133–150.

McCune, B., Mefford, M.J., 1999. Multivariate Analysis of Ecological Data Version 4.01. MjM Software, Gleneden Beach, OR.

Morton, E.S., 1992. What do we know about the future of migrant landbirds? In: Hagan, J.M., Johnston, D.W. (Eds.), Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Institution Press, pp. 579–589.

Murphy, M.T., 2003. Avian population trends within the evolving agricultural landscape of eastern and central United States. Auk 120, 20–34.

Nilsson, C., Dynesius, M., 1994. Ecological effects of river regulation on mammals and birds: a review. Regul. Rivers Res. Manage. 9, 45–53.

Poesen, J., Nachtergaele, J., Verstraeten, G., Valentin, C., 2003. Gully erosion and environmental change: importance and research needs. Catena 50, 91–133.

Saab, V., 1999. Importance of spatial scale to habitat use by breeding birds in riparian forests: a hierarchical analysis. Ecol. Appl. 9, 135–151.

Shields Jr., F.D., Knight, S.S., Cooper, C.M., 1995. Rehabilitation of watersheds with incising channels. Water Resour. Bull. 31, 971–982.

Shields Jr., F.D., Smiley Jr., P.C., Cooper, C.M., 2002. Design and management of edge-of-field water control structures for ecological benefits. J. Soil Water Conserv. 57, 151–157.

Smith, W.P., Pashley, D.N., 1994. A Workshop to Resolve Conflicts in Conservation of Migratory Landbirds in Bottomland Hardwood Forests. General technical report SO-114. U.S. Department of Agriculture, Washington, DC, 37 pp.

Trest, J.W., 1997. Design of structures for the Yazoo Basin Demonstration Erosion Control project. In: Wang, S.Y., Langendoen, E., Shields, Jr., F.D. (Eds.), Management of Landscapes Disturbed by Channel Incision: Stabilization, Rehabilitation, and Restoration. University of Mississippi, pp. 1017–1022.

Vanhinsbergh, D., Gough, S., Fuller, R.J., Brierley, E.D.R., 2002. Summer and winter bird communities in recently established farm woodlands in lowland England. Agric. Ecosyst. Environ. 92, 123–136.

Zar, J.H., 1984. Biostatistical Analysis. Prentice Hall, Englewood Cliffs, NJ, 718 pp.